What is claimed is:

1. A method of forming an air gap within a semiconductor structure comprising the steps of:

using a sacrificial material to occupy a closed interior volume in a semiconductor structure;

causing the sacrificial material to decompose into one or more gaseous decomposition products; and

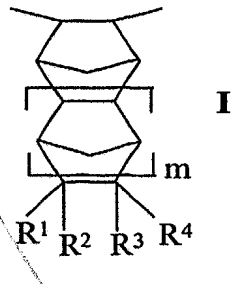
removing at least one of the one or more gaseous decomposition products by passage through at least one solid layer contiguous to the interior volume; and

wherein the decomposition of the sacrificial material leaves an air gap at the closed interior volume previously occupied thereby, and the sacrificial material comprises a norbornene-type polymer.

2. A method as set forth in claim 1, wherein the at least one solid layer is a dielectric material through which the at least one of the one or more gaseous decomposition products can pass by diffusion under conditions not detrimental to the semiconductor structure.

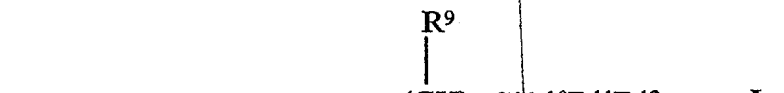
3. A method as set forth in claim 1, wherein the at least one solid layer is a porous dielectric material through which the at least one of the one or more gaseous decomposition products can pass through pores in the porous dielectric material under conditions not detrimental to the semiconductor structure.

4. A method as set forth in claim 1, wherein said norbornene-type polymer comprises repeat units of the general formula:



I

wherein R^1 and R^4 independently represent hydrogen or linear or branched (C_1 to C_{20}) alkyl; R^2 and R^3 independently represent hydrogen, linear or branched (C_1 to C_{20}) alkyl or the groups:



Ia

R^9 independently is hydrogen, methyl, or ethyl; R^{10}, R^{11}, and R^{12} independently represent linear or branched (C_1 to C_{20}) alkyl, linear or branched (C_1 to C_{20}) alkoxy, linear or branched (C_1 to C_{20}) alkyl carbonyloxy, linear or branched (C_1 to C_{20}) alkyl peroxy, and substituted or unsubstituted (C_6 to C_{20}) aryloxy; m is a number from 0 to 4; and n is a number from 0 to 5; and at least one of substituents R^2 and R^3 is selected from the silyl group represented by the formula set forth under **Ia**.

5. A method as set forth in claim 4, wherein at least one of R^{10}, R^{11}, or R^{12} is selected from a linear or branched (C_1 to C_{10}) alkoxy group and R^9 is hydrogen.

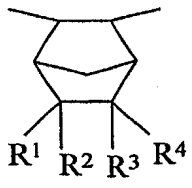
6. A method as set forth in claim 5, wherein each of R^{10}, R^{11}, and R^{12} are the same and are selected from methoxy, ethoxy, propoxy, butoxy, and pentoxy.

7. A method as set forth in claim 6, wherein n is 0 and R^{10}, R^{11}, and R^{12} are each ethoxy groups.

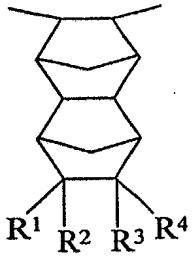
8. A method as set forth in claim 7, wherein R^2 or R^3 is a triethoxysilyl substituent.

9. A method as set forth in claim 1, wherein in Formula **I** above, m is preferably 0 or 1 as represented by structures **Ib** and **Ic**, respectively:

Ib

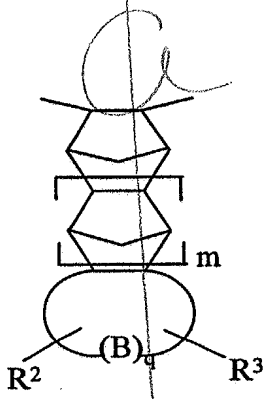


Ic



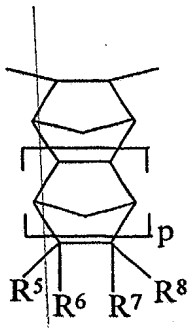
wherein R^1 to R^4 are as previously defined and at least one of R^2 and R^3 is a silyl substituent represented by **Ia**.

10. A method as set forth in claim 1, wherein R^1 and R^4 taken together with the two ring carbon atoms to which they are attached comprise a repeat unit of the following structure:



wherein B is a methylene group, q is a number from 2 to 6, and R^2 and R^3 are as defined above.

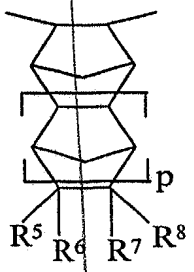
11. A method as set forth in claim 1, wherein said norbornene-type polymer further comprises hydrocarbyl substituted polycyclic repeating units selected from units represented by Formula II below:



II

wherein R^5, R^6, R^7, and R^8 independently represent hydrogen, linear and branched (C_1 to C_{20}) alkyl, hydrocarbyl substituted and unsubstituted (C_5 to C_{12}) cycloalkyl, hydrocarbyl substituted and unsubstituted (C_6 to C_{40}) aryl, hydrocarbyl substituted and unsubstituted (C_7 to C_{15}) aralkyl, (C_3 to C_{20}) alkynyl, linear and branched (C_3 to C_{20}) alkenyl, or vinyl; any of R^5 and R^6 or R^7 and R^8 can be taken together to form a (C_1 to C_{10}) alkylidenyl group, R^5 and R^8 when taken with the two ring carbon atoms to which they are attached can represent saturated and unsaturated cyclic groups containing 4 to 12 carbon atoms or an aromatic ring containing 6 to 17 carbon atoms; and p is 0, 1, 2, 3, or 4.

12. A method as set forth in claim 1, wherein said norbornene-type polymer comprises hydrocarbyl substituted polycyclic repeating units selected from units represented by Formula II below:

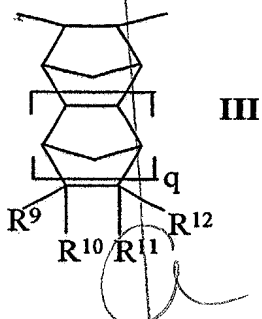


II

wherein R^5, R^6, R^7, and R^8 independently represent hydrogen, linear and branched (C_1 to C_{20}) alkyl, hydrocarbyl substituted and unsubstituted (C_5 to C_{12}) cycloalkyl, hydrocarbyl substituted and unsubstituted (C_6 to C_{40}) aryl, hydrocarbyl substituted and unsubstituted (C_7 to C_{15}) aralkyl, (C_3 to C_{20}) alkynyl, linear and branched (C_3 to C_{20}) alkenyl, or vinyl; any of R^5 and R^6 or R^7 and R^8 can be taken

together to form a (C_1 to C_{10}) alkylidenyl group, R^5 and R^8 when taken with the two ring carbon atoms to which they are attached can represent saturated and unsaturated cyclic groups containing 4 to 12 carbon atoms or an aromatic ring containing 6 to 17 carbon atoms; and p is 0, 1, 2, 3, or 4.

13. A method as set forth in claim 1, wherein said norbornene-type polymer comprises repeating units represented by Formula III below:

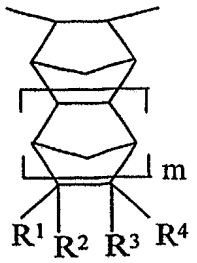


III

wherein R^9 to R^{12} independently represent a polar substituent selected from the group: $-(A)_n-C(O)OR''$, $-(A)_n-OR''$, $-(A)_n-OC(O)R''$, $-(A)_n-OC(O)OR''$, $-(A)_n-C(O)R''$, $-(A)_n-OC(O)C(O)OR''$, $-(A)_n-O-A'-C(O)OR''$, $-(A)_n-OC(O)-A'-C(O)OR''$, $-(A)_n-C(O)O-A'-C(O)OR''$, $-(A)_n-C(O)-A'-OR''$, $-(A)_n-C(O)O-A'-OC(O)OR''$, $-(A)_n-C(O)O-A'-O-A'-C(O)OR''$, $-(A)_n-C(O)O-A'-OC(O)C(O)OR''$, $-(A)_n-C(R'')_2CH(R'')(C(O)OR'')$, and $-(A)_n-C(R'')_2CH(C(O)OR'')_2$; the moieties A and A' independently represent a divalent bridging or spacer radical selected from divalent hydrocarbon radicals, divalent cyclic hydrocarbon radicals, divalent oxygen containing radicals, and divalent cyclic ethers and cyclic diethers; and r is an integer 0 or 1.

14. A method as set forth in claim 1, wherein said norbornene-type polymer comprises copolymers comprising a combination of repeating units represented by Formulae I and II, Formulae I and III, Formulae II and III or Formulae I, II and III, where

Formula I is:



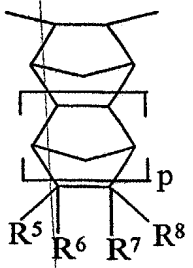
I

wherein R^1 and R^4 independently represent hydrogen or linear or branched (C_1 to C_{20}) alkyl; R^2 and R^3 independently represent hydrogen, linear or branched (C_1 to C_{20}) alkyl or the groups:

Ia

R^9 independently is hydrogen, methyl, or ethyl; R^{10}, R^{11}, and R^{12} independently represent linear or branched (C_1 to C_{20}) alkyl, linear or branched (C_1 to C_{20}) alkoxy, linear or branched (C_1 to C_{20}) alkyl carbonyloxy, and substituted or unsubstituted (C_6 to C_{20}) aryloxy; m is a number from 0 to 4; and n is a number from 0 to 5; and at least one of substituents R^2 and R^3 is selected from the silyl group represented by the formula set forth under **Ia**;

Formula **II** is

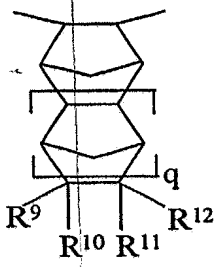


II

wherein R^5, R^6, R^7, and R^8 independently represent hydrogen, linear and branched (C_1 to C_{20}) alkyl, hydrocarbyl substituted and unsubstituted (C_5 to C_{12}) cycloalkyl, hydrocarbyl substituted and unsubstituted (C_6 to C_{40}) aryl, hydrocarbyl substituted and unsubstituted (C_7 to C_{15}) aralkyl, (C_3 to C_{20}) alkynyl, linear and

branched (C_3 to C_{20}) alkenyl, or vinyl; any of R^5 and R^6 or R^7 and R^8 can be taken together to form a (C_1 to C_{10}) alkylidenyl group, R^5 and R^8 when taken with the two ring carbon atoms to which they are attached can represent saturated and unsaturated cyclic groups containing 4 to 12 carbon atoms or an aromatic ring containing 6 to 17 carbon atoms; and p is 0, 1, 2, 3, or 4; and

Formula **III** is



III

wherein R^9 to R^{12} independently represent a polar substituent selected from the group: $-(A)_n-C(O)OR''$, $-(A)_n-OR''$, $-(A)_n-OC(O)R''$, $-(A)_n-OC(O)OR''$, $-(A)_n-C(O)R''$, $-(A)_n-OC(O)C(O)OR''$, $-(A)_n-O-A'-C(O)OR''$, $-(A)_n-OC(O)-A'-C(O)OR''$, $-(A)_n-C(O)O-A'-C(O)OR''$, $-(A)_n-C(O)-A'-OR''$, $-(A)_n-C(O)O-A'-OC(O)OR''$, $-(A)_n-C(O)O-A'-O-A'-C(O)OR''$, $-(A)_n-C(O)O-A'-OC(O)C(O)OR''$, $-(A)_n-C(R'')_2CH(R'')(C(O)OR'')$, and $-(A)_n-C(R'')_2CH(C(O)OR'')_2$; the moieties A and A′ independently represent a divalent bridging or spacer radical selected from divalent hydrocarbon radicals, divalent cyclic hydrocarbon radicals, divalent oxygen containing radicals, and divalent cyclic ethers and cyclic diethers; and n is an integer 0 or 1.

15. A method as set forth in claim 1, wherein the repeating units containing silyl functional groups comprise at least 1 mole percent of the polymer.

16. A method as set forth in claim 15, wherein the repeating units containing silyl functional groups comprise at least 5 mole percent of the polymer.

17. A method as set forth in claim 1, wherein the sacrificial material is provided in the semiconductor structure by:

forming a patterned layer of the sacrificial material on a substrate corresponding to a pattern of one or more gaps to be formed in the semiconductor structure; and

forming another layer of material overlying the patterned layer of sacrificial material.

18. A method as set forth in claim 1, wherein the sacrificial material is provided in the semiconductor structure by:

forming a patterned layer of sacrificial material on a substrate corresponding to a pattern of one or more gaps to be formed in the semiconductor structure;

depositing a second material on the substrate within regions bordered by the sacrificial material;

forming another layer of material overlying the patterned layer of sacrificial material and second material in the regions bordered by the sacrificial material.

19. A method as set forth in claim 18, wherein the depositing step includes using a conductive material as the second material to form conductive leads.

20. A semiconductor device produced in accordance with the method of claim 1.

21. A method of forming one or more air gaps in a semiconductor structure comprising the steps of:

forming a patterned layer of sacrificial material on a substrate corresponding to a pattern of one or more gaps to be formed in the semiconductor structure;

depositing a second material on the substrate within regions bordered by the sacrificial material;

forming an overcoat layer of material overlying the patterned layer of sacrificial material and second material in the regions bordered by the sacrificial material;

causing the sacrificial material to decompose into one or more gaseous decomposition products; and

removing at least one of the one or more gaseous decomposition products by passage through the overcoat layer so that one or more air gaps are formed within the semiconductor structure.

22. A method as set forth in claim 21, wherein said depositing of the second material includes using a conductive material to form conductive leads on opposite sides of portions of the sacrificial material.

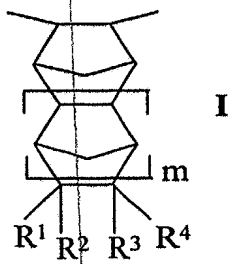
23. A method as set forth in claim 22, wherein prior to said forming of the overcoat layer, the conductive material is formed with a height less than the height of the adjacent sacrificial material.

24. A method as set forth in claim 21, wherein said sacrificial material is a cyclic olefin.

25. A method as set forth in claim 24, wherein said cyclic olefin is a dicyclic olefin.

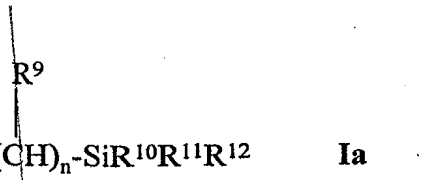
26. A method as set forth in claim 21, wherein said sacrificial material is a norbornene-type polymer.

27. A method as set forth in claim 26, wherein said norbornene-type polymer comprises repeat units of the general formula:



I

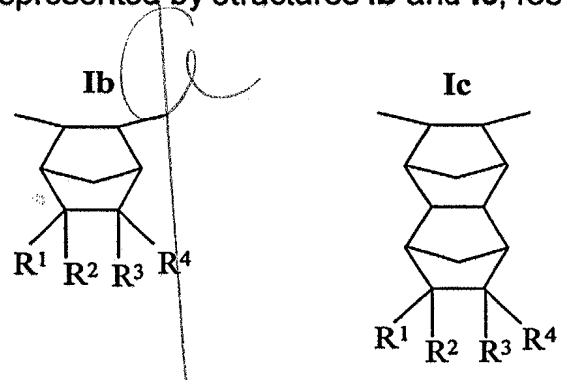
wherein R^1 and R^4 independently represent hydrogen or linear or branched (C_1 to C_{20}) alkyl; R^2 and R^3 independently represent hydrogen, linear or branched (C_1 to C_{20}) alkyl or the groups:



$$-(CH)_n\text{-}SiR^{10}R^{11}R^{12} \qquad \textbf{Ia}$$

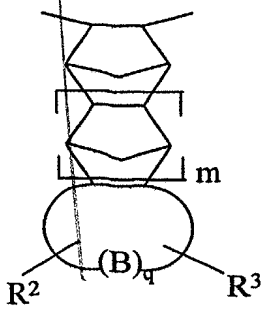
R^9 independently is hydrogen, methyl, or ethyl; R^{10}, R^{11}, and R^{12} independently represent linear or branched (C_1 to C_{20}) alkyl, linear or branched (C_1 to C_{20}) alkoxy, linear or branched (C_1 to C_{20}) alkyl carbonyloxy, and substituted or unsubstituted (C_6 to C_{20}) aryloxy; m is a number from 0 to 4; and n is a number from 0 to 5; and at least one of substituents R^2 and R^3 is selected from the silyl group represented by the formula set forth under **Ia**.

28. A method as set forth in claim 27, wherein in Formula I above, m is preferably 0 or 1 as represented by structures **Ib** and **Ic**, respectively:



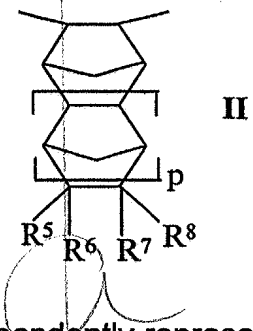
wherein R^1 to R^4 are as previously defined and at least one of R^2 and R^3 is a silyl substituent represented by **Ia**.

29. A method as set forth in claim 27, wherein R^1 and R^4 taken together with the two ring carbon atoms to which they are attached comprise a repeat unit of the following structure:



wherein B is a methylene group, q is a number from 2 to 6, and R^2 and R^3 are as defined above.

30. A method as set forth in claim 27, wherein said norbornene-type polymer further comprises hydrocarbyl substituted polycyclic repeating units selected from units represented by Formula II below:



II

wherein R^5, R^6, R^7, and R^8 independently represent hydrogen, linear and branched (C_1 to C_{20}) alkyl, hydrocarbyl substituted and unsubstituted (C_5 to C_{12}) cycloalkyl, hydrocarbyl substituted and unsubstituted (C_6 to C_{40}) aryl, hydrocarbyl substituted and unsubstituted (C_7 to C_{15}) aralkyl, (C_3 to C_{20}) alkynyl, linear and branched (C_3 to C_{20}) alkenyl, or vinyl; any of R^5 and R^6 or R^7 and R^8 can be taken together to form a (C_1 to C_{10}) alkylidenyl group, R^5 and R^8 when taken with the two ring carbon atoms to which they are attached can represent saturated and unsaturated cyclic groups containing 4 to 12 carbon atoms or an aromatic ring containing 6 to 17 carbon atoms; and p is 0, 1, 2, 3, or 4.

31. A semiconductor device produced in accordance with the method of claim 21.

32. A method of forming an air gap within a structure comprising the steps of:

using a sacrificial material to occupy a closed interior volume in the structure;

heating the sacrificial material to cause it to decompose into one or more gaseous decomposition products; and

removing at least one of the one or more gaseous decomposition products by passage through at least one solid layer contiguous to the interior volume; and

wherein the decomposition of the sacrificial material leaves an air gap at the closed interior volume previously occupied by the sacrificial material.

33. A method as set forth in claim 32, wherein the at least one solid layer is a dielectric material through which the at least one of the one or more gaseous decomposition products can pass by diffusion under conditions not detrimental to the semiconductor structure.

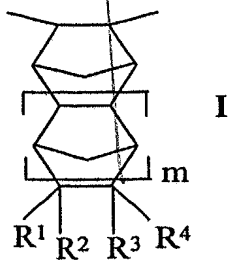
34. A method as set forth in claim 32, wherein the at least one solid layer is a porous dielectric material through which the at least one of the one or more gaseous decomposition products can pass through pores in the porous dielectric material under conditions not detrimental to the semiconductor structure.

35. A method as set forth in claim 32, wherein said sacrificial material is a cyclic olefin.

36. A method as set forth in claim 35, wherein said cyclic olefin is a bicycloolefin.

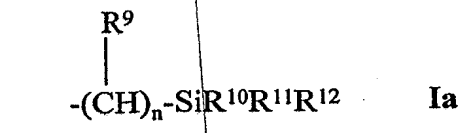
37. A method as set forth in claim 32, wherein said sacrificial material is a norbornene-type polymer.

38. A method as set forth in claim 37, wherein said norbornene-type polymer comprises repeat units of the general formula:



I

wherein R^1 and R^4 independently represent hydrogen or linear or branched (C_1 to C_{20}) alkyl; R^2 and R^3 independently represent hydrogen, linear or branched (C_1 to C_{20}) alkyl or the groups:

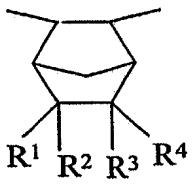


Ia

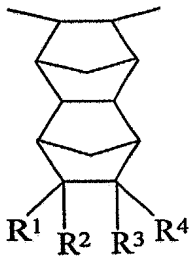
R^9 independently is hydrogen, methyl, or ethyl; R^{10}, R^{11}, and R^{12} independently represent linear or branched (C_1 to C_{20}) alkyl, linear or branched (C_1 to C_{20}) alkoxy, linear or branched (C_1 to C_{20}) alkyl carbonyloxy, and substituted or unsubstituted (C_6 to C_{20}) aryloxy; m is a number from 0 to 4; and n is a number from 0 to 5; and at least one of substituents R^2 and R^3 is selected from the silyl group represented by the formula set forth under **Ia**.

39. A method as set forth in claim 38, wherein in Formula I above, m is preferably 0 or 1 as represented by structures **Ib** and **Ic**, respectively:

Ib

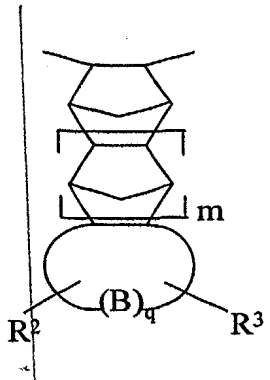


Ic



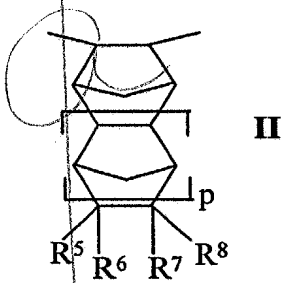
wherein R^1 to R^4 are as previously defined and at least one of R^2 and R^3 is a silyl substituent represented by **Ia**.

40. A method as set forth in claim 38, wherein R^1 and R^4 taken together with the two ring carbon atoms to which they are attached comprise a repeat unit of the following structure:



wherein B is a methylene group, q is a number from 2 to 6, and R^2 and R^3 are as defined above.

41. A method as set forth in claim 38, wherein said norbornene-type polymer further comprises hydrocarbyl substituted polycyclic repeating units selected from units represented by Formula II below:



II

wherein R^5, R^6, R^7, and R^8 independently represent hydrogen, linear and branched (C_1 to C_{20}) alkyl, hydrocarbyl substituted and unsubstituted (C_5 to C_{12}) cycloalkyl, hydrocarbyl substituted and unsubstituted (C_6 to C_{40}) aryl, hydrocarbyl substituted and unsubstituted (C_7 to C_{15}) aralkyl, (C_3 to C_{20}) alkynyl, linear and branched (C_3 to C_{20}) alkenyl, or vinyl; any of R^5 and R^6 or R^7 and R^8 can be taken together to form a (C_1 to C_{10}) alkylidenyl group, R^5 and R^8 when taken with the two ring carbon atoms to which they are attached can represent saturated and unsaturated cyclic groups containing 4 to 12 carbon atoms or an aromatic ring containing 6 to 17 carbon atoms; and p is 0, 1, 2, 3, or 4.

42. A semiconductor device produced in accordance with the method of claim 32.

Add A2>

Add 7 C3